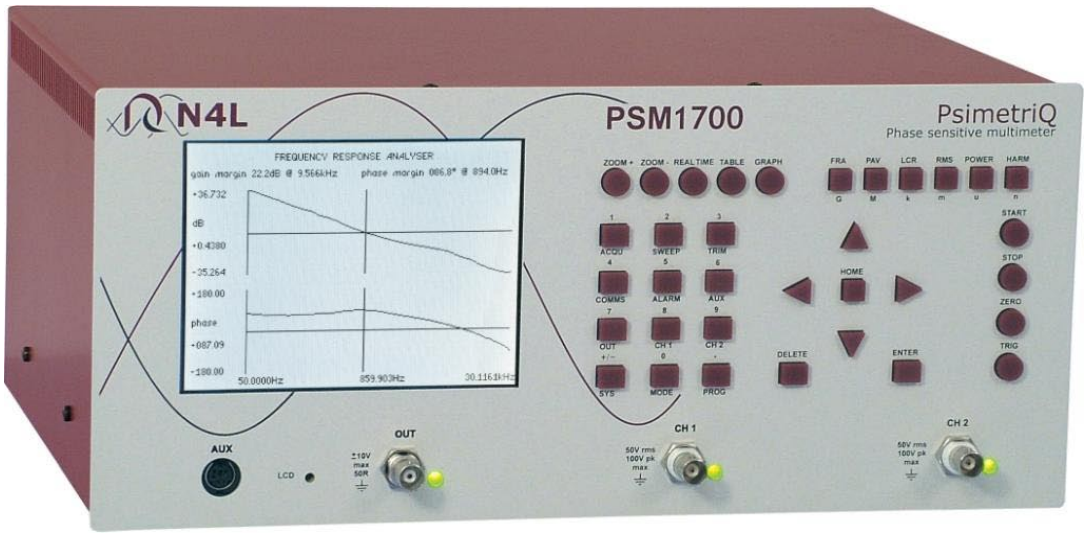
PSM1700 - *PsimetriQ*

USER MANUAL



“ Do not be hasty when making measurements.”

PsimetriQ is a precision instrument that provides you with the tools to make a wide variety of measurements accurately, reliably, and efficiently - but good metrology practice must be observed. Take time to read this manual and familiarise yourself with the features of the instrument in order to use it most effectively.

DANGER OF ELECTRIC SHOCK
Only qualified personnel should install this equipment, after reading and understanding this user manual. If in doubt, consult your supplier.

RISQUE D'ELECTROCUTION
L'installation de cet équipement ne doit être confiée qu'à un personnel qualifié ayant lu et compris le présent manuel d'utilisation. Dans le doute, s'adresser au fournisseur.

GEFAHR VON ELEKTRISCHEM SCHOCK
Nur entsprechend ausgebildetes Personal ist berechtigt, diese Ausrüstung nach dem Lesen und Verständnis dieses Anwendungshandbuches zu installieren. Falls Sie Zweifel haben sollten, wenden Sie sich bitte an Ihren Lieferanten.

RISCHIO DI SCARICHE ELETTRICHE
Solo personale qualificato può installare questo strumento, dopo la lettura e la comprensione di questo manuale. Se esistono dubbiconsultate il vostro rivenditore.

PELIGRO DE DESCARGA ELÉCTRICA
Solo personal cualificado debe instalar este instrumento, después de la lectura y comprensión de este manual de usuario. En caso de duda, consultar con su suministrador.

IMPORTANT SAFETY INSTRUCTIONS

This equipment is designed to comply with BSEN 61010-1 (Safety requirements for electrical equipment for measurement, control, and laboratory use) – observe the following precautions:

- Ensure that the supply voltage agrees with the rating of the instrument printed on the back panel ***before*** connecting the mains cord to the supply.
- This appliance ***must*** be earthed. Ensure that the instrument is powered from a properly grounded supply.
- The inputs must not be connected to signals greater than 50V rms or 100V pk.
- Keep the ventilation holes on the underneath and sides free from obstruction.
- Do not operate or store under conditions where condensation may occur or where conducting debris may enter the case.
- There are no user serviceable parts inside the instrument – do not attempt to open the instrument, refer service to the manufacturer or his appointed agent.

Note: Newtons4th Ltd. shall not be liable for any consequential damages, losses, costs or expenses arising from the use or misuse of this product however caused.

DECLARATION OF CONFORMITY

Manufacturer: Newtons4th Ltd.
Address: 1 Bede Island Road
Leicester
LE2 7EA

We declare that the product:

Description: Phase Sensitive Multimeter
Product name: PsimetriQ
Model: PSM1700

conforms to the requirements of Council Directives:

89/336/EEC relating to electromagnetic compatibility:
EN 61326:1997 Class A

73/23/EEC relating to safety of laboratory equipment:
EN 61010-1

April 2004

Eur Ing Allan Winsor BSc CEng MIEE
(Director Newtons4th Ltd.)

WARRANTY

This product is guaranteed to be free from defects in materials and workmanship for a period of 36 months from the date of purchase.

In the unlikely event of any problem within this guarantee period, first contact Newtons4th Ltd. or your local representative, to give a description of the problem. Please have as much relevant information to hand as possible – particularly the serial number and release numbers (press SYSTEM then LEFT).

If the problem cannot be resolved directly then you will be given an RMA number and asked to return the unit. The unit will be repaired or replaced at the sole discretion of Newtons4th Ltd.

This guarantee is limited to the cost of the PsimetriQ itself and does not extend to any consequential damage or losses whatsoever including, but not limited to, any loss of earnings arising from a failure of the product or software.

In the event of any problem with the instrument outside of the guarantee period, Newtons4th Ltd. offers a full repair and re-calibration service – contact your local representative. It is recommended that PsimetriQ be re-calibrated annually.

ABOUT THIS MANUAL

PsimetriQ has of number of separate measurement functions that share common resources such as the keyboard and display.

Accordingly, this manual first describes the general features and specification of the instrument as a whole; and then describes the individual functions in detail.

Each function is described in turn, in its own chapter, with details of the principles on which it is based, how to use it, the options available, display options, specifications etc.

Detailed descriptions of the RS232 command set is given in the separate manual “PSM17xx communications manual”.

Revision 1.62

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21 October 2010

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1 Introduction – general principles of operation

PsimetriQ is a self-contained test instrument, with one output and two inputs, which incorporates a suite of test functions.

PsimetriQ has a versatile generator output that can be used as signal generator for the following waveforms:

- sine,
- triangle
- square
- sawtooth

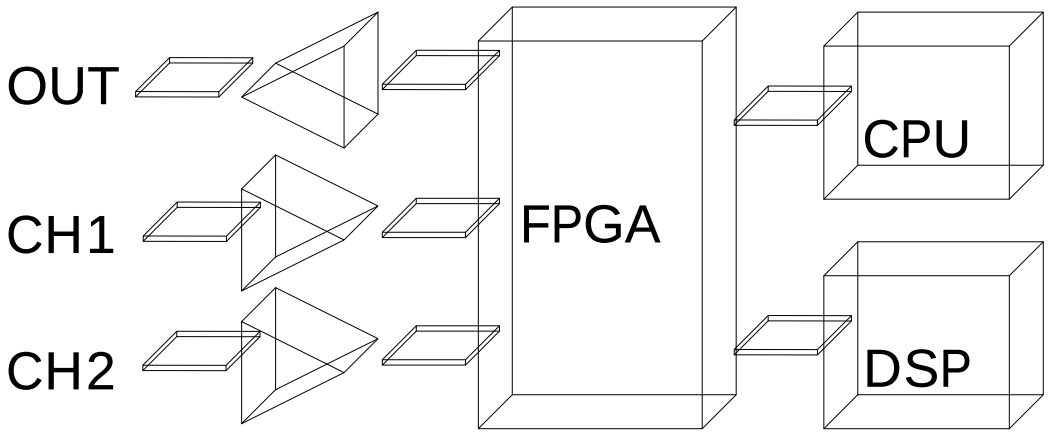
A dc offset may be added to the signal generator output.

PsimetriQ has two differential, wide range, high bandwidth, voltage inputs.

The PsimetriQ has two processors:

- a DSP (digital signal processor) for data analysis
- a CPU (central processing unit) for control and display

At the heart of the system is an FPGA (field programmable gate array) that interfaces the various elements.



This general purpose structure provides a versatile hardware platform that can be configured by firmware to provide a variety of test functions, including:

signal generator
two channel true rms voltmeter
phase angle voltmeter (vector voltmeter)
frequency response analyser (gain/phase analyser)
harmonic analyser

With additional external interface boxes, such as current shunts, other functions are possible:

true rms current meter
LCR meter
power meter

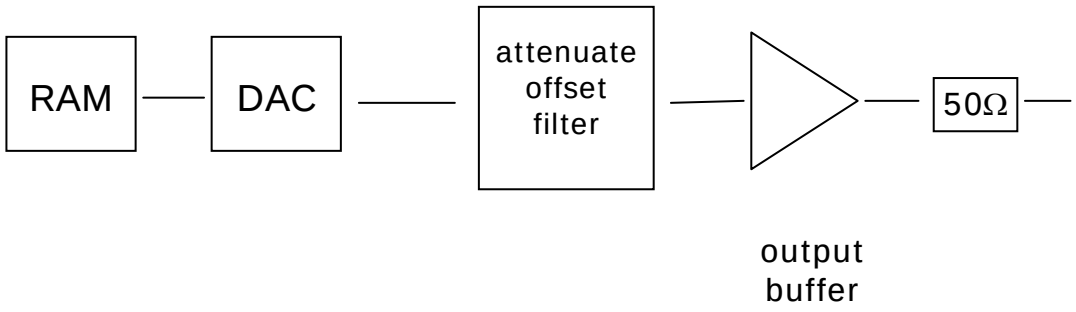
PsimetriQ is configured to perform the required test function by simple user menus, or can be controlled remotely via a serial interface (RS232), or optionally LAN interface or GPIB interface.

The programmable nature of the instrument means that new functions can be added as they become available, or existing functions can be enhanced, by simple firmware download.

1.1 Generator output

The generator consists of a DAC whose input is derived from a table held in RAM. The appropriate pattern is loaded into the RAM (sinewave, sawtooth etc.) by the DSP, and then the RAM address is stepped at a rate given by the selected frequency. The output of the DAC is attenuated, has any offset added, is filtered and is buffered by a high speed, high current buffer.

The DAC is clocked at 11.52 MHz.
The DAC resolution is 14 bit.
The RAM depth is 16k words x 16 bit.
The maximum output level is ±10V peak.
The maximum output current is ±200mA peak.
The 0V of the output is earthed.
There is a 50Ω output impedance.

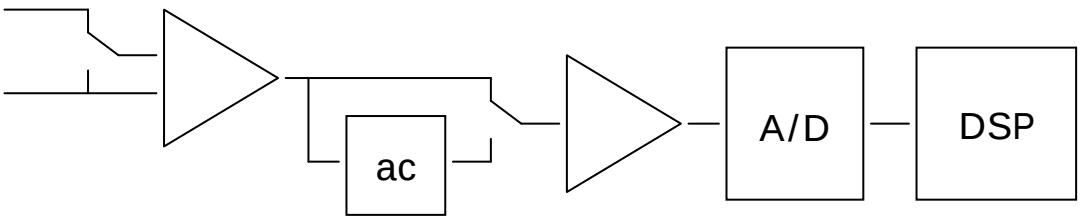


1.2 Voltage inputs

Each input consists of a high impedance buffer followed by switch to select ac or ac+dc coupling, then a series of gain stages leading to an A/D converter. Selection of the input gain and the sampling of the A/D converter are under the control of the DSP. There is an autozero switch at the front end for dc accuracy.

Both input channels are fully differential with very good CMRR. This allows measurements to be made directly across points in a circuit without shorting to earth. It also prevents problems with ground loops in sensitive circuits.

The maximum input is ±100V peak (50V rms).
The full scale of the lowest range is ±10mV peak.
The input frequency range is dc to 1 MHz.
The A/D converter resolution is 12 bit.
The A/D sample rate is variable to 500k samples/s.



2 Getting started

The PsimetriQ is supplied ready to use – it comes complete with an appropriate power lead and a set of test leads. It is supplied calibrated and does not require anything to be done by the user before it can be put into service.

2.1 Unpacking

Inside the carton there should be the following items:

- one PsimetriQ unit
- one appropriate mains lead
- two voltage probes
- one BNC output lead with clips
- one null modem cable to connect to a computer
- this manual

Having verified that the entire above list of contents is present, it would be wise to verify that your PsimetriQ operates correctly and has not been damaged in transit.

First verify that the voltage rating on the rear of the PsimetriQ is appropriate for the supply, then connect the mains cord to the inlet on the rear panel of the PsimetriQ and the supply outlet.

Switch on the PsimetriQ. The display should illuminate with the model name and the firmware version for a few seconds while it performs some initial tests. It should then default to the RMS voltmeter display. Note that the switch on message can be personalised – see the User Data section under System Options.

Note that if there are no leads connected, the rms display should read zero. If any test leads are connected then

because of the high impedance of the inputs, the rms display may read some random values due to noise pick up. If the unit does display any values with no leads connected, give the unit thirty minutes to warm up then press ZERO.

Connect the output lead to the output connector of the PsimetriQ and the input probes to the two input connectors. Connect the output to both of the inputs by connecting the black clip on the output lead to the 0V clip on each of the input probes, and the red clip of the output lead to the input probes. Note that this is easiest to do by connecting across a resistor (any value above 1k).

Press the OUT key to invoke the output menu, then press the UP key to select the output on/off control then the RIGHT key to turn on the output.

Exit the menu by pressing the ENTER button or the HOME button *twice.*

The display should now indicate an rms value of ~1.4V on both channels, each of which should indicate the 3V range.

Press the FRA key to select the frequency response (gain phase) analyser function and check that the gain reads 0dB ±0.02dB, and that the phase reads ≤ 0.01°.

In the event of any problem with this procedure, please contact customer services at Newtons4th Ltd. or your local authorised representative: contact addresses and telephone numbers are given in the appendix at the back of this manual.

2.2 Keyboard and controls

The keyboard is divided into 5 blocks of keys:

- display control (5 keys top left)
- function keys (6 keys top right)
- setup keys (middle 12 keys)
- menu control keys (7 centre keys)
- action keys (4 keys lower right)

In normal operation, the cursor keys give one-touch adjustment of various parameters, such as generator amplitude and frequency, without having to access the menu system.

The setup keys provide access to the menus and are used for numeric data entry.

The function keys (FRA, PAV, LCR, RMS, POWER and HARM) are also used for entering the multipliers (G, M, k, m, u, n) for date entry and letters for text entry.

2.3 Basic operation

Once the unit has powered on and is displaying the default RMS voltmeter screen, the required function can be selected by pressing the function key, FRA, PAV, LCR, RMS, POWER, HARM. Pressing the same function key again brings up the menu options specific to that function. For example, after the unit has powered on in RMS mode, press PAV to select phase angle voltmeter mode; press PAV again to gain access to the PAV specific menu options.

Alternatively, press MODE to bring up the function specific menus.

There are a number of menus available to configure the instrument. All of these menus are directly accessible with one press of the appropriate menu key. The cursor keys allow navigation around the menus and also control the generator when not accessing a menu.

For example, to turn on the output, press OUT to bring up the generator control menu, press UP to select the output on/off option, press RIGHT to turn on the output. Press ENTER, or HOME twice, to exit the menu. Press FRA to select frequency response analyser mode and the instrument will now display the gain and phase of the transfer function of the circuit under test at the spot frequency specified by the output control menu.

Press LEFT or RIGHT to adjust the frequency, Press UP or DOWN to adjust the amplitude (use the OUT menu to change the size of the steps).

Press START and PsimetriQ will start a frequency sweep over the specified range (set in the SWEEP menu); press TABLE to see the table of results, GRAPH to see a graph of the results and REAL TIME to return to the real time data.

3 Using the menus

PsimetriQ is a very versatile instrument with many configurable parameters. These parameters are accessed from the front panel via a number of menus.

Each of the main menus may be accessed directly from a specific key.

ACQU	data acquisition parameters such as speed and filtering
SWEEP	frequency sweep control
TRIM	generator trim (amplitude compression) control
REMOTE	communications options (RS232 etc)
MONITOR	control of audible alarm and analogue output
AUX	control of auxiliary devices connected to either the front AUX port or rear EXTENSION port
OUT	signal generator control
CH1	channel 1 input control
CH2	channel 2 input control
SYSTEM	general system options such as phase convention, keyboard beep etc.
MODE	function control
PROG	recall/store/ delete of non-volatile programs

Each menu starts with the currently set parameters visible but no cursor. In this condition, pressing the menu key again or the HOME key aborts the menu operation and reverts back to normal operation.

To select any parameter, press the UP or DOWN key and a flashing box will move around the menu selecting each parameter. In this condition the keys take on their secondary function such as numbers 0-9, multipliers n-G etc.

Pressing the HOME key first time reverts to the opening state where the parameters are displayed but the cursor is hidden. Pressing the HOME key at this point exits the menu sequence and reverts back to normal operation.

To abort the menu sequence, press the HOME key twice.

There are three types of data entry:

- selection from a list
- numeric
- text

3.1 Selection from a list

This data type is used where there are only specific options available such as the output may be ‘on’ or ‘off’, the graph drawing algorithm may use ‘dots’ or ‘lines’.

When the flashing cursor is highlighting the parameter, the RIGHT key steps forward through the list, and the LEFT key steps backwards through the list. The number keys 0-9 step directly to that point in the list, which provides a quick way to jump through long lists. There is no need to press the ENTER key with this data type

For example, if the waveform selection list comprises the options:

sinewave	(item 0)
triangle wave	(item 1)
square wave	(item 2)
leading sawtooth	(item 3)
trailing sawtooth	(item 4)

and the presently selected option is sinewave, there are 3 ways to select leading sawtooth:

press RIGHT three times
press LEFT twice
press number 3

3.2 Numeric data entry

Parameters such as frequency and offset are entered as real numbers; frequency is an example of an unsigned parameter, offset is an example of a signed parameter.

Real numbers are entered using the number keys, multiplier keys, decimal point key, or +/- key (if signed value is permitted). When the character string has been entered, pressing the ENTER key sets the parameter to the new value. Until the ENTER key is pressed, pressing the HOME key aborts the data entry and restores the original number.

If a data value is entered that is beyond the valid limits for that parameter then a warning is issued and the parameter set as close to the requested value as possible. For example, the maximum amplitude of the PsimetriQ generator is 10V peak; if a value of 15V is entered, a warning will be given and the amplitude set to the maximum of 10V.

When the parameter is first selected there is no character cursor visible – in this condition, a new number may be entered directly and will overwrite the existing number.

To edit a data value rather than overwrite it, press the RIGHT key and a cursor will appear. New characters are inserted at the cursor position as the keys are pressed, or the character before the cursor position can be deleted with the DELETE key.

Data values are always shown in engineering notation to at least 5 digits (1.0000-999.99 and a multiplier).

3.3 Text entry

There are occasions where it is useful to enter a text string; for example, a non-volatile program may have some text as a title.

Text is entered by selecting one of 6 starting characters using the display control keys on the top row of the keyboard, then stepping forwards or backwards through the alphabet with the UP and DOWN keys.

The starting letters from left to right are A, E, I, O, U, or space.

Numbers can also be inserted using the number keys.

The UP and DOWN keys step forward and backward using the ASCII character definitions – other printable characters such as # or ! can be obtained by stepping on from the space. The available character set is given in the Appendix.

When entering alphabetic characters, the ZOOM+ and ZOOM- keys select upper and lower case respectively for the character preceding the cursor and the next characters to be entered.

The editing keys, RIGHT, LEFT, DELETE and ENTER operate in the same way as for numeric entry.

4 Special functions

4.1 Display zoom

PsimetriQ normally displays many results on the screen in a combination of small font size (no zoom) and up to 4 values in a larger font size (first zoom level). There is also an even larger font for up to 4 selected values (second zoom level).

To set the data values for the larger font size, first return to no zoom by pressing ZOOM-, twice if necessary. Press ZOOM+ key to view the presently selected data, and press DELETE to clear the selection.

A flashing box surrounds the first available result. The flashing box is moved around the available results using the cursor keys, UP, DOWN, LEFT and RIGHT. Pressing the ENTER key selects the result for zoom and the box ceases to flash. Further results (up to four in total) can then be selected using the cursor keys in the same way – a solid box remains around the already selected item, and a new flashing box appears.

Having selected the desired results, pressing the ZOOM+ key invokes the first zoom level, pressing it again selects the higher level. Pressing ZOOM-, steps back down one level each time.

Note that any of the parameters selected for the zoom function can be used as the input for the alarm monitoring and analogue output.

4.2 Program store and recall

There are 100 non-volatile program locations where the settings for the entire instrument can be saved for recall at a later date. Each of the 100 locations has an associated name of up to 20 characters that can be entered by the user to aid identification.

Program number 1 (if not empty) is loaded when the instrument is powered on, so that PsimetriQ can be set to a user defined state whenever it is switched on. This is particularly useful to set system options such as phase convention. If no settings have been stored in program 1 then the factory default settings are loaded (program number 0).

Program numbers 1-6 may be recalled with a single press of the function keys if the direct load option is selected in the system menu (see system options).

The instrument can be restored to the factory default settings at any time by recalling program number 0.

The program menu is accessed using the PROG key. The program location can be selected either by stepping through the program locations in turn to see the name, or by entering the program number directly.

When storing a configuration in a program, there will be a slight pause (of about 1 second) if the program has previously been written or deleted. The process will be very quick if the location has not been used.

When supervisor mode is disabled (see system options), programs can only be recalled, not stored nor deleted, to avoid accidental modification.

4.3 Zero compensation

There are 3 levels of zero compensation:

Trim out the dc offset in the input amplifier chain.
Measure any remaining offset and compensate.
Measure parasitic external values and compensate.

The trim of the dc offset in the input amplifier chain is re-applied every time that the measurement function is changed, or can be manually invoked with the ZERO key, or over the RS232 with the REZERO command.

The measurement of the remaining offset also happens when the offset is trimmed but is also repeated at regular intervals when using a measurement function that requires dc accuracy (such as the rms voltmeter). This is to compensate for any thermal drift in the amplifier chain. This repeated autozero function can be disabled via the SYSTEM OPTIONS menu.

The compensation for parasitic external values (for example to compensate for the capacitance of the test leads when measuring capacitance) is invoked manually by the ZERO key. Refer to each function section for the function specific operations.

Any compensation values are stored along with the instrument configuration when a program is stored.

To restore operation without function specific compensation press ZERO then DELETE.

4.4 Alarm function

PsimetriQ has two independent alarms that can be read remotely or can generate an audible sound Each of the alarms can be triggered by comparison to one or two thresholds:

sound the alarm if the value exceeds a threshold
sound the alarm if the value is below a threshold
sound the alarm if the value is outside a window
sound the alarm if the value is inside a window

Additionally, one of the alarms can be used to generate a sound which varies linearly between thresholds

The value to which each alarm is applied can be any of the measurements selected for zoom. The alarm status is also available as a logic output on the parallel port.

To program an alarm, first select the functions for the zoom; up to four measurements can be selected for the display, the alarm is applied to any of them; then press ALARM to invoke the alarm menu:

select which of the zoom functions is to be used
select the type of alarm
set the upper limit (if appropriate)
set the lower limit (if appropriate)
select whether the alarm is to be latched
select whether the alarm sounder is enabled

If the alarm latch is selected then the alarm will continue to sound even if the value returns to within the normal boundaries. To clear the alarm, press HOME.

The linear alarm option allows tests to be carried out even if it is not possible to see the display. Pressing ZERO in the alarm menu sets the upper and lower threshold to 4/3 and

1/3 of the measured value respectively. The repetition rate of the sounder then varies linearly as the value changes between these thresholds.

4.5 Analogue output

The analogue output is a 0 to 4V dc level that represents the selected measurement.

To program the analog output, first select the functions for the zoom; up to four measurements can be selected for the display, the alarm is applied to any one of them; then press ALARM to invoke the alarm and analog output menu:

select which of the zoom functions is to be used
set the value for zero volts output
set the analog scaling factor

The analog output level is computed as:

output voltage = 4 * scale * (measurement – zero)

The output is updated whenever new data is available. For maximum update speed, select “fast analogue output” mode in the ACQU menu and enter a window value for 10ms or higher. When START is pressed, the instrument enters a special mode where all non-essential functions are suppressed (including the display). Press STOP to return to the normal display.

4.6 Data hold

When in real time display mode, the data on the display can be held at any time by pressing the REAL TIME key. When HOLD is activated a warning message is briefly displayed and the word HOLD appears in the top right hand corner of the display.

Press the REAL TIME key again or the HOME key or START key to release HOLD; in this case, HOME and START do not have their normal functions. Changing mode also releases hold.

When HOLD has been activated, the DSP continues to sample, compute and filter the results but the data is ignored by the CPU. When HOLD is released the display is updated with the next available value from the DSP.

4.7 Parallel port

PsimetriQ has a logic level parallel port with 8 output lines and 4 input lines, which can be used to interface with other parts of a test system or with a PLC.

The parallel port can be used either as a general purpose I/O port under communications control (see PPORT and PPORT? commands) or can be used as a status output:

7	6	5	4	3	2	1	0
				ALM2	ALM1	ERR	DAV

bit 0 DAV data available
bit 1 ERR data error (under or overrange)
bit 2 ALM1 alarm 1
bit 3 ALM2 alarm 2

The status output is enabled in the ALARM menu. By selecting appropriate alarm conditions, the status output can be used as a pass/fail indicator

Parallel port pin connections:

pin	function	
2-9	data out	D0 [pin 2] – D7 [pin 9]
10	data in	D2
11	data in	D3
12	data in	D0
13	+5V supply	50mA max.
15	data in	D1

4.8 Sweep results store and recall

There are 30 non-volatile storage locations that can store the results of frequency sweeps. Each location can store the sweep results for up to 50 points; larger sweeps can be stored in multiple locations:

frequency points in sweep	locations used per sweep	memory capacity
up to 50	1	30
51-100	2	15
101-150	3	10
151-200	4	7
201-250	5	6
251-500	8	3
501-1000	15	2
1001-2000	30	1

When storing a sweep, a text string may be entered to help identify the data.

Each stored sweep also saves the instrument configuration along with the sweep results (same as program store/recall), so that the instrument is restored to the same settings when the sweep is recalled.

The sweep data may be restored manually or via communications for download to a PC. To manually access the sweep data store, press PROG and select memory type “sweep”.

5 Using remote control

PsimetriQ is fitted with an RS232 serial communications port as standard, and may have an IEEE488 (GPIB) interface or LAN interface fitted as an option. All the interfaces use the same ASCII protocol with the exception of the end of line terminators:

	Rx expects	Tx sends
RS232	carriage return (line feed ignored)	carriage return and line feed
LAN	carriage return (line feed ignored)	carriage return and line feed
IEEE488	carriage return or line feed or EOI	carriage return with EOI

All the functions of the PsimetriQ can be programmed via either interface, and results read back. When the IEEE488 interface is set to ‘remote’ the RS232 port is ignored.

The commands are not case sensitive and white space characters are ignored (e.g. tabs and spaces). Replies from PsimetriQ are always upper case, delimited by commas, without spaces.

Only the first six characters of any command are important – any further characters will be ignored. For example, the command to set the generator frequency is FREQUE but the full word FREQUENCY may be sent as the redundant NCY at the end will be ignored.

Fields within a command are delimited by comma, multiple commands can be sent on one line delimited with a semi-colon. Eg.

AMPLIT,1.5;OUTPUT,ON

Mandatory commands specified in the IEEE488.2 protocol have been implemented, (e.g. *IDN?, *RST) and all

commands that expect a reply are terminated with a question mark.

PsimetriQ maintains an error status byte consistent with the requirements of the IEEE488.2 protocol (called the standard event status register) that can be read by the mandatory command *ESR? (see section 5.1).

PsimetriQ also maintains a status byte consistent with the requirements of the IEEE488.2 protocol, that can be read either with the IEEE488 serial poll function or by the mandatory command *STB? over RS232 or IEEE or LAN (see section 5.2).

The IEEE address defaults to 23 and can be changed via the COMMS menu.

The keyboard is disabled when the instrument is set to “remote” using the IEEE or if the command “KEYBOA,DISABL” is sent. Press HOME to return to “local”.

RS232 data format is: start bit, 8 data bits (no parity), 1 stop bit. Flow control is RTS/CTS (see section 5.2), baud rate is selectable via the MONITOR menu.

A summary of the available commands is given in the Appendix. Details of each command are given in the communication command section of the manual.

Commands are executed in sequence except for two special characters that are immediately obeyed:

Control T (20) – reset interface (device clear)
Control U (21) – warm restart

To maintain compatibility with some communication systems, there is an optional “protocol 2” which requires a space between the command and any arguments.

5.1 Standard event status register

PON		CME	EXE	DDE	QYE		OPC

bit 0 OPC (operation complete)
cleared by most commands
set when data available or sweep complete
bit 2 QYE (unterminated query error)
set if no message ready when data read
bit 3 DDE (device dependent error)
set when the instrument has an error
bit 4 EXE (execution error)
set when the command cannot be executed
bit 5 CME (command interpretation error)
set when a command has not been recognised
bit 7 PON (power on event)
set when power first applied or unit has reset

The bits in the standard event status register except for OPC are set by the relevant event and cleared by specific command (*ESR?, *CLS, *RST). OPC is also cleared by most commands that change any part of the configuration of the instrument (such as MODE or START).

5.2 Serial Poll status byte

		ESB	MAV	ALM	FDV	SDV	RDV

bit 0 RDV (result data available)
set when results are available to be read as enabled by DAVER

bit 1 SDV (sweep data available)
set when sweep results are available to be read as enabled by DAVER

bit 2 FDV (fast data available (streaming))
set when data streaming results are available to be read as enabled by DAVER

bit 3 ALA (alarm active)
set when an alarm is active and enabled by ALARMER

bit 4 MAV (message available)
set when a message reply is waiting to be read

bit 5 ESB (standard event summary bit)
set if any bit in the standard event status register is set as well as the corresponding bit in the standard event status enable register (set by *ESE).

5.3 RS232 connections

The RS232 port on PsimetriQ uses the same pinout as a standard 9 pin serial port on a PC or laptop (9-pin male ‘D’ type).

Pin	Function	Direction
1	DCD	in (+ weak pull up)
2	RX data	in
3	TX data	out
4	DTR	out
5	GND	
6	DSR	not used
7	RTS	out
8	CTS	in
9	RI	not used

PsimetriQ will only transmit when CTS (pin 8) is asserted, and can only receive if DCD (pin 1) is asserted. PsimetriQ constantly asserts (+12V) DTR (pin 4) so this pin can be connected to any unwanted modem control inputs to force operation without handshaking. PsimetriQ has a weak pull up on pin 1 as many null modem cables leave it open circuit. In electrically noisy environments, this pin should be driven or connected to pin 4.

To connect PsimetriQ to a PC, use a 9 pin female to 9 pin female null modem cable:

1 & 6	-	4
2	-	3
3	-	2
4	-	1 & 6
5	-	5
7	-	8
8	-	7

5.4 Data streaming

The phase angle voltmeter and power meter modes have the option of high speed data streaming. In this operation, the window width for the measurement may be specified from 660us to 100ms and the data for each measurement window is transmitted over the communications in a continuous stream. The window is adjusted to synchronise to the measured frequency.

PsimetriQ buffers the data and transmits at the fastest rate that is possible. The buffer depth is over 8000 data values so more than 5 seconds of data can be captured at the fastest rate of 1500 readings per second even if the data is not read at all. If the window size is such that the data can be read out in real time then data streaming can continue indefinitely.

Once the data streaming window has been setup but before the streaming has been started, the display periodically shows the measured value. Once streaming has been started, the display is blanked to minimise processing overheads. Streaming can be stopped either immediately (ABORT) or may be stopped but remaining data continues to be transmitted until the buffer is empty (STOP).

STREAM,ENABLE,0.01
START
read data
STOP
continue to read stored data

6 System options

Press SYSTEM to access the system options.

Measurements of phase can be expressed in one of three conventional formats:

-180° to +180° (commonly used in circuit analysis)
0° to -360° (commonly used in power applications)
0° to +360°

The measurement is exactly the same it is only the way that it is expressed that changes.

Blanking can be applied to a number of measurements so that zero is shown when the measurement is below a certain level. This blanking can be disabled if desired.

The graphs on the display and printout may be made up of single points or lines.

Each key press is normally accompanied by an audible ‘beep’ as well as the tactile ‘click’. The ‘beep’ can be disabled for quiet environments if the feel of the key is sufficient feedback

Regular autozero measurements can be suppressed.

Any measurements that are expressed in units of length (eg. LVDT) can be displayed in metres or inches.

The shunt value is usually selected automatically when changing function to one that needs a current input such as power meter or LCR meter. If the shunt is set to ‘manual’ rather than ‘default’ then the shunt value will not be changed.

When stepping through frequency or amplitude using the cursor keys in real time mode, a message is usually

displayed showing the new value. This message can be disabled.

The 6 main function keys, FRA, PAV, LCR, RMS, POWER, HARM, can be used to load stored configurations as a “one-touch” way of configuring the instrument for specific applications. This is particularly useful in a production environment where an operator has a small number of specific tests to perform.

Levels are usually expressed in volts but can be set and displayed in dBm, which is a logarithmic scale referred to 1mW in 600Ω, often used when testing communications components.

To save these system settings as default, store the setup in program 1 so that they are reloaded on power on.

Pressing RIGHT from the SYSTEM OPTIONS menu selects the USER DATA screen.

Pressing LEFT from first SYSTEM OPTIONS menu displays the serial number, release versions, and calibration date.

6.1 User data

PsimetriQ can be personalised by entering up to 3 lines of user data as text (see section on text entry).

User data is displayed every time that the instrument is switched on to identify the instrument. The entered text may also be read over the communications to identify the instrument (see USER?).

Typical arrangement of the user data might be:

line 1 company name
line 2 department or individual name
line 3 unique identifying number (eg. asset number)

Any user data may be entered as required, as the lines are treated purely as text and are not interpreted by PsimetriQ at all.

For use in a production environment, PsimetriQ supports two modes of operation, supervisor and user. When supervisor mode is disabled, the stored programs can only be recalled, not changed. In user mode PsimetriQ will also not accept any commands which could change the calibration data.

After changing the user data or supervisor status, execute ‘store’ to save the data in non-volatile memory.

7 Measurement options

7.1 ACQU - Acquisition options

In normal acquisition mode the window over which the measurements are computed is adjusted to give an integral number of cycles of the input waveform. The results from each window are passed through a digital filter equivalent to a first order RC low pass filter.

There are four pre-set speed options - fast, medium, slow, and very slow – that adjust the nominal size of the window, and therefore the update rate and the time constant of the filter. Greater stability is obtained at the slower speed at the expense of a slower update rate.

There is also an option to set a specific size of the window to a value other than the preset options. In order to synchronise to an integral number of cycles, the window size is either reduced by up to 25% or increased as necessary.

Note that the window is always extended to cover at least one complete cycle of the input waveform even if this is a longer period than the nominal update rate.

Each window can be specified as comprising a minimum number of cycles the waveform. This extends the measurement window for lower frequencies. The window time consists of the longer of the selected speed and the minimum number of cycles.

To allow for settling of the circuitry under test, there is a programmable delay before making a measurement.

The phase measurement is usually referenced to CH1 but can be changed to CH2. This has the result of reversing the measured phase.

There are two time constants for the filter, normal or slow, or the filter can be deselected. The filter applies an auto reset function to give a fast dynamic response to a change of measurement – this function can be deselected and the filter forced to operate with a fixed time constant for use with noisy signals.

The nominal values are:

speed	update rate	normal time constant	slow time constant
fast	1/20s	0.2s	0.8s
medium	1/3s	1.5s	6s
slow	2.5s	12s	48s
very slow	10s	48s	192s

The filter dynamics are usually set to “auto reset” where the filtering is reset in response to a significant change in data. This speeds up the response of the instrument to changing conditions. This function can be disabled so that the filtering has a fixed time constant, which would have an exponential response to a step change.

When the generator is not used and so the measurement is synchronised to the input frequency measured on CH1, there is a low frequency option that extends the frequency measurement down to 20mHz. This low frequency option also applies a digital filter, which can be useful when measuring in a low frequency, noisy environment.

There are 3 further modes apart from ‘normal’:

Data streaming is a special high speed mode for use with communications to a PC – see section on RS232.

Fast analogue output mode suppresses the display in order to speed up the processing for analogue output update.

Single measurement mode makes individual measurements in response to a trigger – manually via the keypad or *TRG over the communications. After the measurement the output can be specified to be switched off, left on, left on with dc only, or left with dc only at a specific phase of the waveform. By setting the measurement window appropriately, this mode allows the output to be controlled so that it is only on for the duration of a single measurement. Note that the output will always be on for a longer duration than the window period because of settling and ranging time prior to starting the acquisition. The duration is typically 25% longer than the requested window.

7.2 Datalog

PsimetriQ can store and display measurements recorded at regular intervals over a time period. Each data record consists of the elapsed time and up to four data values selected by ZOOM. More than 8000 records can be stored if one value is selected; more than 3000 if four values are selected.

The actual interval between data points is governed by the measurement speed and the datalog interval. PsimetriQ stores the next available measurement after the datalog interval has elapsed: the actual elapsed time is attached to each datalog record, is displayed with the data on the table or each graph, and returned with each record over the communications (RS232, LAN or GPIB).

The data values may be stored to RAM or directly into non-volatile memory as each value becomes available. The non-volatile option is useful for acquiring data over long periods, to prevent the loss of data in the event of a power failure. Data that has been stored into RAM may be subsequently transferred to non-volatile memory using the PROG menu. In this mode the data may be viewed in real time, as it is being acquired.

For high speed data acquisition, the datalog interval may be set to zero so that each measurement is stored. The measurement interval is controlled with the “speed” option in the ACQU menu. Using the “window” option for speed allows greater control of the measurement interval. In this mode, the display flashes “DATALOG RUNNING” and only shows the acquisition time. The minimum datalog interval depends on the function but is typically 10ms.

Note that in all cases the measurement interval is necessarily adjusted to be an integral number of cycles of the measured waveform.

The datalog options are set up with the ACQU menu. The datalog is started with the START key, and stopped with the STOP key unless the store becomes full first. The zero reference for the elapsed time is taken as the first data measurement after START.

The data can be viewed as a table or as individual graphs. Pressing GRAPH steps the graph through the stored parameters. If more than 250 records have been stored, the graph can show the data for the whole period or pressing ZOOM redraws the graph to show 250 records about the cursor. The cursor can be moved in single steps (LEFT or RIGHT) or large steps (UP or DOWN). Pressing UNZOOM shows the whole data gain. Movements of the cursor are synchronised in both the TABLE and GRAPH views.

7.3 SWEEP - Frequency sweep options

All ac measurements using the PsimetriQ generator can be swept across a frequency range. The start frequency, stop frequency and number of steps up to 2000 can be specified. The measurements are subjected to the same speed constraints set in the ACQU menu, but the filtering does not apply on each measurement point. If continuous sweep is selected, then the filtering is applied to each successive sweep.

At the end of a sweep the generator may be set to stay on, switch off, dc only with immediate effect or to drive the ac to zero at a specific phase of the waveform. If selected to stay on, the generator settings revert back to those specified in the normal generator menu;

The frequency steps may be set to be logarithmically or linearly spaced. Logarithmic spacing usually gives the clearest display of frequency dependent parameters but linear spacing can be useful in some applications.

The graph normally sets the y axis automatically to the extremes of the measurements (or in FRA mode to 20dB/decade of frequency) but the axis can be fixed if required. The graph of the second parameter (usually phase) can also be independently manually set.

A vertical marker can be placed on the graph to reference a specific frequency.

For visual comparison to a reference part with a known response, the reference response can be kept on the display drawn with a dotted line while new sweeps are made:

1. Set the graph scaling manually.
2. Perform a sweep with the reference part.
3. Press ZERO to set the reference display.

4. Perform a sweep with the part to be compared.

Each frequency point is an entirely new measurement and autoranging is restarted (if enabled). For the fastest possible sweeps, select manual ranging. As each frequency point is a new measurement, filtering has no effect on a single sweep, but fixed time filtering can be applied independently on each frequency point if repeat sweep in selected.

For maximum sweep speed, particularly when using a large number of points, there is a “fast sweep” mode which disables all non-essential functions, including the display, during the sweep. In this mode the display is blank except for a flashing message “ACQUIRING SWEEP DATA” until the full sweep has been completed when normal display functions are restored. This mode is automatically selected when a user defined window of less than 100ms has been set.

Up to 30 sweeps may be stored in non-volatile memory using the PROG key. Sweeps are stored in blocks of 50 points, larger sweeps use contiguous blocks eg:

steps in sweep	blocks per sweep	max number of sweeps
2-50	1	30
51-100	2	15
101-150	3	10
151-200	4	7
201-250	5	6
251-500	8	3
501-1000	15	2
1001-2000	30	1

7.4 TRIM - Trim function

The trim function on PsimetriQ is a powerful and versatile feature that allows closed loop control of the generator amplitude. It allows a specific measurement to be programmed for either CH1 and CH2 and the generator output will be adjusted to maintain the measured voltage or current. This allows the excitation level to be controlled over changing conditions such as a frequency sweep.

At each measurement point, the measured level is checked against the specified level and tolerance; if an adjustment is needed the data is discarded and a new measurement made at the new output level. The user is alerted to the adjustment by an audible beep.

Particularly important in control loop analysis, where it is sometimes referred to as amplitude compression, it prevents the control loop being overdriven as the frequency changes.

It is also useful in a more general case where test levels are specified.

Note that when dBm mode level control is selected, the trim level is entered as dBm but the tolerance remains a linear percentage of the actual voltage not the logarithmic dBm measure.

8 Output control

The output for the signal generator is digitally synthesised at an update rate of 11.52Msamples/s. This gives very good sinewave waveform, even at 1MHz, while preserving very accurate frequency control. Output filtering removes the stepped effect of the sampling.

The output for the signal generator passes through a linear 10 bit attenuator giving amplitude increments of approximately 10mV.

An offset may be added to any output to bias the signal or to null out any dc present.

The LEFT and RIGHT keys adjust the frequency of the generator by a fixed increment stored via the STEP menu; the UP and DOWN keys adjust the amplitude (except for the harmonic analyser and power analyser where UP and DOWN step the selected harmonic).

The generator output may be set to be on, off, dc only with immediate effect or to drive the ac to zero at a specific phase of the waveform.

8.1 Generator specifications

General	
accuracy	frequency ±0.05% amplitude ±5% (to 100kHz)
accuracy (with trim)	amplitude ±1% (to 1MHz)
output impedance	50Ω ±2%
output voltage	±10V peak
offset	±10V peak maximum
waveforms	sine, triangle, square, sawtooth
frequency	10uHz to 1MHz
type	direct digital synthesis
update rate	11.52MHz
DAC resolution	14 bit
cycle width	14 bit

9 Input channels

The two input channels are differentially isolated from each other and from earth, and are controlled independently but sampled synchronously.

Each input channel may be selected to be:

- disabled
- voltage
- external shunt

If the external shunt option is selected, the data is scaled by the shunt value (entered under the relevant channel menu) and the units are displayed in Amps. Any resistor can be used as a shunt, or precision low inductance current shunts are available as accessories. Current transformers can be used if fitted with an appropriate burden resistor.

Note that the external shunt input polarity is reversed compared to that of the voltage input: ie the outer screen of the input connector is positive and the inner contact is negative. This is so that the capacitance to ground of the probe cable screen is driven with the lower source impedance in order to minimise errors at high frequency.

Note that some modes force the input channels to be voltage or current automatically, eg. the power meter defaults to channel 1 as voltage and channel 2 as current. This automatic selection can be overridden if required.

The input ranges have nominal full scale values set with a ratio of 1:√10 from 10mV to 100V. This gives the following ranges:

range	reference	nominal full scale
1	10mV	10mV
2	30mV	31.6mV
3	100mV	100mV
4	300mV	316mV
5	1V	1V
6	3V	3.16V
7	10V	10V
8	30V	31.6V
9	100V	100V

The ranges may be selected manually, or by autoranging (default). The start range for autoranging may be selected if it is known that the signal will not be below a certain level.

There is also an option to autorange ‘up only’ so that a test may be carried out to find the highest range. Once the highest range has been determined, the range can be set to manual and the test carried out without losing any data due to range changing. Pressing the HOME key (or sending *TRG) restarts the autoranging from the selected minimum range.

When in an input channel menu, the ZERO key provides a quick way to lock and unlock the range. When no flashing box is visible in the input channel menu and autoranging is selected, pressing the ZERO key selects the range that the instrument is currently using and sets the autoranging to manual, thus locking the range and preventing further autoranging. Pressing the ZERO key again returns to full autoranging from the bottom range.

For most measurement functions full autoranging is the most suitable option but some applications, such as where transient events are occurring, are more reliable with

manual ranging. Manual ranging (or up-only autoranging) is essential for low frequency measurements.

For measuring signals that are biased on a dc level (such as an amplifier operating on a single supply or the output of a dc PSU), ac coupling can be used. AC+DC coupling is the normal option and should be used where possible.

A scaling factor can be entered for each channel for use with attenuators such as x10 oscilloscope probes. A nominal value can be entered or the attenuation factor of the probe can be measured and the precise value entered. The measured voltage will be displayed after multiplication by the scale factor.

If the channel has been set for use with an external shunt then the value of the shunt can be entered.

9.1 Trimming x10 oscilloscope probes

To use a x10 oscilloscope probe at high frequency the probe needs to be trimmed to match the input capacitance of the instrument. A small plastic screwdriver is provided with each probe for this purpose.

To the probes, connect the instrument output across a convenient resistor (anything above 1k) using the supplied BNC to crocodile clip output lead. Connect the probes from CH1 and CH2 also across the resistor.

Press OUT and set the generator to 1kHz squarewave with 2V amplitude. Press HARM to invoke harmonic analyser mode and select third harmonic.

With both probes set to x1, the measured third harmonic should read 33.33% +/- 0.03%. Select x10 on one of the probes and adjust the trimmer in the body of the probe until the third harmonic again reads 33.33%. Switch the probe back to x1 and verify that the third harmonic reads the same. Repeat the adjustment if necessary. Select x10 on the other probe and adjust in the same way.

To verify the adjustment at higher frequency, select the 25^{th} harmonic for measurement. The reading should be approximately 4% in both x1 and x10 settings.

10 True RMS Voltmeter

The RMS voltmeter measures the total rms of the signal present at the input terminals to the bandwidth of the instrument (>1MHz). Care must be taken when measuring low signal levels to minimise noise pick on the input leads.

The RMS voltmeter measures the elementary values:

- rms
- dc
- peak
- surge

and derives the values: ac, dBm and crest factor.

The rms value of a periodic waveform, $v(\phi)$, is given by:

$$rms = \sqrt{\left[\; 1/2\pi \int_{0}^{2\pi} v^2(\phi) \, d\phi \; \right]}$$

For a sampled signal, the formula becomes:

$$rms = \sqrt{\left[\; 1/n \sum_{i=0}^{i=n-1} v^2[i] \; \right]}$$

where n is the number of samples for an integral number of complete cycles of the input waveform.

These are fundamental definitions that are valid for all waveshapes. For a pure sinewave, the formulae equate to peak/√2, but this cannot be applied to other waveshapes. PsimetriQ computes the true rms value from the fundamental definition for sampled data.

The dc present is given by:

$$dc = 1/2\pi \int_{0}^{2\pi} v(\phi)\, d\phi$$

For a sampled signal, the formula becomes:

$$dc = 1/n \sum_{i=0}^{i=n-1} v[i]$$

where n is the number of samples for an integral number of complete cycles of the input waveform.

Having computed the true rms and the dc component, the ac component can be derived from:

$$rms^2 = ac^2 + dc^2 \qquad => \qquad ac^2 = rms^2 - dc^2$$

The ac component is also expressed in dB referred to 1mW into 600Ω (dBm):

$$dBm = 20 \log (Vac/Vref)$$

where $Vref = \sqrt{(1mW \times 600\Omega)}$

or $20 \log (Iac/Iref)$

where $Iref = \sqrt{(1mW / 600\Omega)}$

The peak measurement is simply the value with the largest magnitude. Positive and negative peaks are independently filtered then the result with the largest magnitude is taken as the peak value.

In order to measure surge conditions, the maximum instantaneous peak value (unfiltered) is also recorded. It is

important that PsimetriQ does not autorange while measuring surge – either set the range to manual or repeat the test with ranging set to up only. To reset the maximum, press START.

Crest factor is derived from the peak and rms:

cf = peak / rms

The measurements are computed over rectangular windows with no gaps. The processing power of the DSP allows the measurements to be made in real time without missing any samples. In this way, the measured rms is a true value even if the signal is fluctuating. The only occasion when data is missed is when an autozero measurement is requested – this can be disabled in the SYTEM OPTIONS menu if required.

The ZOOM function can be used to select any combination of up to four parameters from the display.

10.1 RMS voltmeter specification

DVM	
channels	2 differential
display	5 digits
measurement	true rms, ac, dc, dBm, peak, cf, surge
coupling	ac or ac+dc
frequency	dc to >1MHz (ac+dc coupling)
ac coupling cut off	~1.5Hz (–3dB)
max input	±100V peak, 50V rms
input ranges	100V, 30V, 10V, 3V, 1V, 300mV, 100mV, 30mV, 10mV
ranging	full auto, up only, or manual
input impedance	1M // 30pF (exc. leads)
accuracy (ac)	0.05% range + 0.05% reading + 0.2mV <1kHz Basic + 0.02%/KHz < 10KHz Basic + 0.2% + 0.002%/KHz < 1MHz
accuracy (dc)	0.1% range + 0.1% reading + 1mV
CMRR (typical)	60dB @ 50V 50Hz 50dB @ 50V 1kHz 40dB @ 10V 1MHz
time constant	0.2s, 1.5s or 12s

Conditions:

23ºC +/- 5ºC ambient temperature
instrument allowed to warm up for ≥30 minutes
sinewave
slow speed, normal filtering
ac+dc coupling
autoranging or manual ranging ≥ 1/3 range

11 Frequency response analyser

PsimetriQ measures the gain and phase of channel 2 relative to channel 1 using a discrete Fourier transform (DFT) algorithm at the fundamental frequency.

The DFT technique can measure phase as well as magnitude and is inherently good at rejecting noise – it is much more reliable than measuring the rms at one point relative to another point.

The circuit can be characterised by computing the gain and phase at a number of points over a frequency range. This gives results that show the transfer function of the circuit as a graph on the display.

The DFT analysis yields two components – in-phase and quadrature, or ‘a’ and ‘b’ values – from which the magnitude and phase can be derived.

Considering the components at the fundamental frequency:

The fundamental in-phase and quadrature values of a periodic waveform, $v(\phi)$, are given by:

$$a_1 = 1/2\pi \int_0^{2\pi} v(\phi).\cos(\phi)\, d\phi$$

$$b_1 = 1/2\pi \int_0^{2\pi} v(\phi).\sin(\phi)\, d\phi$$

For a sampled signal, the formulae become:

$$a_1 = 1/n \sum_{i=0}^{i=n-1} v[i].\cos(2\pi ci/n)$$

$$b_1 = 1/n \sum_{i=0}^{i=n-1} v[i].\sin(2\pi ci/n)$$

where n is the number of samples for an integral number of complete cycles of the input waveform, and c is the number of cycles.

Having computed the real and quadrature components, the magnitude and phase of each channel can be derived:

$$mag = \sqrt{(a_1^2 + b_1^2)}$$

$$\theta = \tan^{-1}(b_1/a_1)$$

The relative gain and phase of the circuitry under test at that particular frequency is derived from the real and quadrature components by vector division:

vector gain = (a + jb) {ch2} / (a + jb) {ch1}

gain = magnitude (vector gain)

phase = $\tan^{-1}$(b/a (vector gain))

The gain is usually quoted in dB:

$$dB = 20 \log_{10}(gain)$$

The phase difference can be expressed as a delay time:

delay = periodic time x measured phase / 360

To look at differences in gain from a nominal value, an offset gain can be applied either manually or by pressing ZERO.

offset gain = measured dB – offset dB

The filtering is applied to the real and quadrature components individually, rather than the derived magnitude and phase values. This gives superior results as any noise contribution to the components would have random phase and therefore would be reduced by filtering.

PsimetriQ can operate either in real time mode at a single frequency where the gain and phase are filtered and updated on the display; or it can sweep a range of frequencies and present the results as a table or graphs of gain and phase.

The frequency points to be measured are specified with three parameters:

number of steps
start frequency
end frequency

PsimetriQ computes a multiplying factor that it applies to the start frequency for the specified number of steps. Note that due to compound multiplication it is unlikely that the end frequency will be exactly that programmed. The frequency sweep is initiated by the START key, and when completed the data can be viewed as a table or graphs.

Following a sweep on a control loop, the gain and phase margins can be computed and displayed on the graph.

The window over which the measurements are computed is adjusted to give an integral number of cycles of the

input waveform. In real time mode the results from each window are passed through a digital filter equivalent to a first order RC low pass filter; in sweep mode each result comprises a single window without any filtering unless repeat sweep is selected.

The top of the vertical axis for the graph is normally set to be the highest measured value during the sweep. The bottom of the vertical axis is normally either set to the lowest measured value or the result of the highest value less 20dB/decade of frequency. The vertical axis can be fixed to a manual scale using the menus.

The ZOOM function can be used to select up to four parameters from the display when in real time mode. It has no function following a sweep.

Following a sweep the GRAPH key selects between:

graph of gain v frequency
graph of phase v frequency
graph of gain and phase v frequency.

Pressing HOME or TRIG restarts the real time measurement at the selected frequency.

Although it is most usual to use the PsimetriQ generator when performing gain/phase analysis, there may be circumstances where this is impractical, for example measuring across a transformer under load. In this case, turn off the PsimetriQ generator (OUT menu) and the frequency reference for the analysis is measured from channel 1. Provided that the signal is clean enough for an accurate frequency measurement (and for DFT analysis the frequency does need to be accurately known), then the gain and phase can be measured reliably.

When using an external frequency reference there can be no sweep function.

11.1 Frequency response analyser specification

Frequency response (gain/phase) analyser	
frequency	10uHz to1MHz (own generator) 20mHz to 500kHz (external source)
max input	±100V peak 50Vrms
input ranges	100V, 30V, 10V, 3V, 1V, 300mV, 100mV, 30mV, 10mV
ranging	full auto, up only, or manual
input impedance	1M // 30pF (exc. leads)
gain accuracy	0.02 dB < 1kHz 0.05 dB < 10kHz 0.1 dB + 0.001 dB/kHz < 1MHz
phase accuracy	0.02° < 10kHz 0.02° + 0.003°/kHz < 1MHz
sweep step rate	1/20s, 1/3s or 2.5s (approx.)

Conditions:

23ºC +/- 5ºC ambient temperature
instrument allowed to warm up for ≥30 minutes
ac+dc coupling
autoranging or manual ranging ≥ 1/3 range

12 Phase angle voltmeter (vector voltmeter)

A phase angle voltmeter (or vector voltmeter, or phase sensitive voltmeter) measures the signal at one input compared to the phase of the signal at a reference input. The results may be expressed as magnitude and phase, or as separate in-phase and quadrature components.

PsimetriQ measures the in-phase and quadrature components at the fundamental frequency using DFT analysis as described in the section on frequency response analysis. CH2, the measurement input, is phase referred to CH1, the reference input. The individual components are filtered separately to minimise the effects of noise, which would have random phase and would therefore be filtered out. The true rms of the input signals is also computed.

CH1 and CH2 may be voltage inputs or may use external shunts.

From the phase referred fundamental components, (a + jb), the following results can be derived:

magnitude	$= \sqrt{(a^2 + b^2)}$
phase	$= \tan^{-1}(b/a)$
tan ϕ	$= b/a$
in-phase ratio	$= a2 / a1$
LVDT (diff)	$= scale * a2 / a1$
LVDT (ratio)	$= scale * (m1-m2) / (m1+m2)$

where a1 and a2 are the in-phase components, and m1 and m2 are the magnitudes, of the signals present at ch1 and ch2 respectively.

The parameter of interest is selected via the PAV or MODE menu. The frequency and phase are always displayed.

A null meter display may be selected via the PAV menu to allow adjustment of a circuit for minimum phase or component. The parameter on the display depends on the selected component:

parameter	display	null meter
in-phase		in-phase
quadrature		quadrature
tanϕ	tanϕ	tanϕ
magnitude	magnitude	magnitude
phase	phase	
rms	rms	rms2
rms2/1	rms2/rms1	rms2/rms1
in-phase ratio	in-phase ratio	in-phase ratio
LVDT diff	LVDT	LVDT
LVDT ratio	LVDT	LVDT

The null meter may be manually ranged or will automatically range as the signal varies. When manually ranging, ZOOM+ and ZOOM- adjust the range by a decade.

There is a phase offset option that applies a vector rotation of a user selectable phase shift to the CH2 input data.

PsimetriQ can operate either in real time mode at a single frequency where the measurements are filtered and updated on the display; or it can sweep a range of frequencies and present the results as a table or graphs. Before performing a sweep, the desired parameter must be selected.

The frequency points to be measured are specified with three parameters:

number of steps
start frequency
end frequency

PsimetriQ computes a multiplying factor that it applies to the start frequency for the specified number of steps. Note that due to compound multiplication it is unlikely that the end frequency will be exactly that programmed. The frequency sweep is initiated by the START key, and when completed the data can be viewed as a table or graphs or printed out.

The window over which the measurements are computed is adjusted to give an integral number of cycles of the input waveform. In real time mode the results from each window are passed through a digital filter equivalent to a first order RC low pass filter; in sweep mode each result comprises a single window without any filtering.

The ZOOM function can be used to select up to four parameters from the display when in real time mode. It has no function following a sweep.

Although it is most usual to use the PsimetriQ generator when making Phase Angle Voltmeter measurements, there may be circumstances where this is impractical, for example measuring LVDT displacement under actual circuit conditions. In this case, turn off the PsimetriQ generator (OUT menu) and the frequency reference for the analysis is measured from channel 1. Provided that the signal is clean enough for an accurate frequency measurement (and for DFT analysis the frequency does need to be accurately known), then the measurements can be made reliably.

When using an external frequency reference there can be no sweep function.

12.1 Phase angle voltmeter specification

Phase angle voltmeter (vector voltmeter)	
frequency	10uHz to1MHz (own generator) 20mHz to 500kHz (external source)
measurement type	DFT analysis, and true rms
measurements	magnitude, phase, A & B components, B/A, A2/A1, LVDT (diff), LVDT (ratio), rms, rms2/1
max input	±100V peak, 50V rms
input ranges	100V, 30V, 10V, 3V, 1V, 300mV, 100mV, 30mV, 10mV
ranging	full auto, up only, or manual
input impedance	1M // 30pF (exc. leads)
magnitude Basic accuracy	0.05% range + 0.05% reading + 0.05mV <1kHz Basic + 0.02%/KHz < 10KHz Basic + 0.2% + 0.002%/KHz < 1MHz
phase accuracy	0.02° < 1kHz 0.02° + 0.003°/kHz > 1kHz
resolution	0.01°
A/B resolution	0.001
CMRR (typical)	60dB @ 50V 50Hz 50dB @ 50V 1kHz 40dB @ 10V 1MHz
sweep step rate	1/20s, 1/3s or 2.5s (approx.)

Conditions:

23ºC +/- 5ºC ambient temperature
instrument allowed to warm up for ≥30 minutes
ac+dc coupling
autoranging or manual ranging ≥ 1/3 range

13 Power meter

The power meter measures the total power and fundamental power of the signal present at the input terminals to the bandwidth of the instrument (>1MHz).

One of the inputs must be configured as an external shunt input. The external shunt may be a simple resistor or dedicated high frequency precision shunts are available as accessories. Current transformers and clamps may be used if fitted with a suitable burden resistor. For use at mains voltages, a mains power adaptor incorporating voltage and current transformers is available.

The power meter will operate either from its own generator or, more normally, will use the frequency measured on channel 1 (usually voltage).

The power meter measures the elementary values:

- W
- V rms
- A rms
- V fundamental (in-phase and quadrature)
- A fundamental (in-phase and quadrature)
- V dc
- A dc
- V harmonic (in-phase and quadrature)
- A harmonic (in-phase and quadrature)
- frequency

and derives the following values:

- V & A fundamental magnitude
- VA (true and fundamental)
- power factor (true and fundamental)
- fundamental W
- harmonic W
- phase shift

When the integrator function is activated, the following values are available:

Elapsed time (in hours, minutes and seconds)
Watt-hours (true and fundamental)
VA hours (true and fundamental)
average power factor (true and fundamental)
Ampere hours (true and fundamental)

The power dissipated in a load subjected to a periodic voltage, $v(\phi)$, with a current flowing $a(\phi)$, is given by:

$$w = 1/2\pi \int_0^{2\pi} v(\phi).a(\phi)\, d\phi$$

For a sampled signal, the formula becomes:

$$w = 1/n \sum_{i=0}^{i=n-1} v[i].a[i]$$

where n is the number of samples for an integral number of complete cycles of the input waveform.

These are elementary definitions that are valid for all waveshapes. PsimetriQ computes the true watts value from the elementary definition for sampled data. Formulae for the components at the fundamental frequency are given in the section on frequency response analysis; formulae for the harmonic components are given in the section on harmonic analysis.

The formulae for the derived results are:

VA = $V_{rms} \times A_{rms}$
power factor = Watts/VA
fundamental Watts = $V_{real} \times A_{real} + V_{quad} \times A_{quad}$

harmonic Watts = VH_{real} x AH_{real} + VH_{quad} x AH_{quad}
fundamental VA = V_{fund} x A_{fund}
fund power factor = W_{fund} / VA_{fund}

In power meter mode, the UP and DOWN key do not adjust the amplitude but step the harmonic number.

The measurements are computed over rectangular windows with no gaps. The processing power of the DSP allows the measurements to be made in real time without missing any samples. In this way, the measured power is a true value even if the signal is fluctuating. The only occasion when data is missed is when an autozero measurement is requested – this can be disabled in the SYTEM OPTIONS menu.

The high linearity of PsimetriQ allows real-time measurements be made on waveforms with periodic bursts such as low standby power PSUs. Use “autorange up” to find the range.

PsimetriQ blanks the results when either of the measured rms signals are low compared to the full scale range. This function can be disabled if desired in the SYSTEM menu.

The ZOOM function can be used to select any combination of up to four parameters from the display.

The integrator is started, or reset, by pressing the START key. The Watt hour integration and the Ampere hour integration can be selected to be signed or magnitude. To integrate the total power in terms of heating effect, choose magnitude. If signed integration is selected then the rms current is given the sign of the power before integration. The Ampere hours and Watt hours then reflect the power taken by the load, less any power generated by the load, such as during regenerative braking in battery systems.

13.1 Power meter specification

Power meter	
current input	external shunt
display	5 digits
measurement	W, VA, PF, fundamental, rms, phase
coupling	ac or ac+dc
frequency	dc to > 1MHz
	20mHz to 500kHz (fundamentals)
ac coupling cut off	~1.5Hz (–3dB)
max input	±100V peak 50V rms
input ranges	100V, 30V, 10V, 3V, 1V, 300mV,
	100mV, 30mV, 10mV
ranging	full auto, up only, or manual
input impedance	1M // 30pF (exc. leads)
accuracy (ac)	0.15% range + 0.15% reading < 1kHz
	1.5% range + 1.5% reading < 50kHz
	2% range + 8% reading < 1MHz
accuracy (dc)	0.2% range + 0.3% reading
CMRR (typical)	60dB @ 50V 50Hz
	50dB @ 50V 1kHz
	40dB @ 10V 1MHz
time constant	0.2s, 1.5s or 12s

Conditions:

23ºC +/- 5ºC ambient temperature
instrument allowed to warm up for ≥30 minutes
sinewave, power factor > 0.7
slow speed, normal filtering
ac+dc coupling
autoranging or manual ranging ≥ 1/3 range
0.1% current shunt selected to give 100mV rms

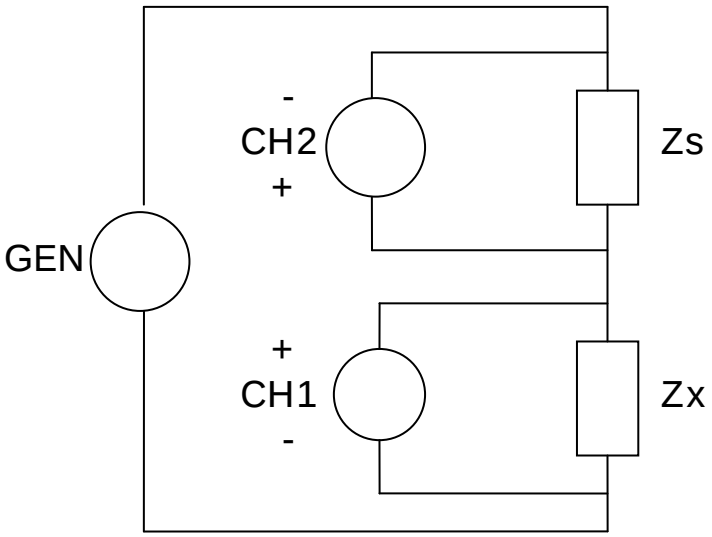
14 LCR meter

In LCR meter mode, channel 1 measures the voltage across the component under test, and channel 2 measures the current through it. To measure the current, channel 2 must be connected across an appropriate external shunt.

The easiest way to use the LCR meter is with the ‘LCR active head’ (see accessories) that fits onto the front of PsimetriQ and provides 4 wire Kelvin clip connections to the component under test. The active head provides a choice of shunts, selectable from the front panel, and buffers the signals to minimise the effects of stray capacitance and inductance.

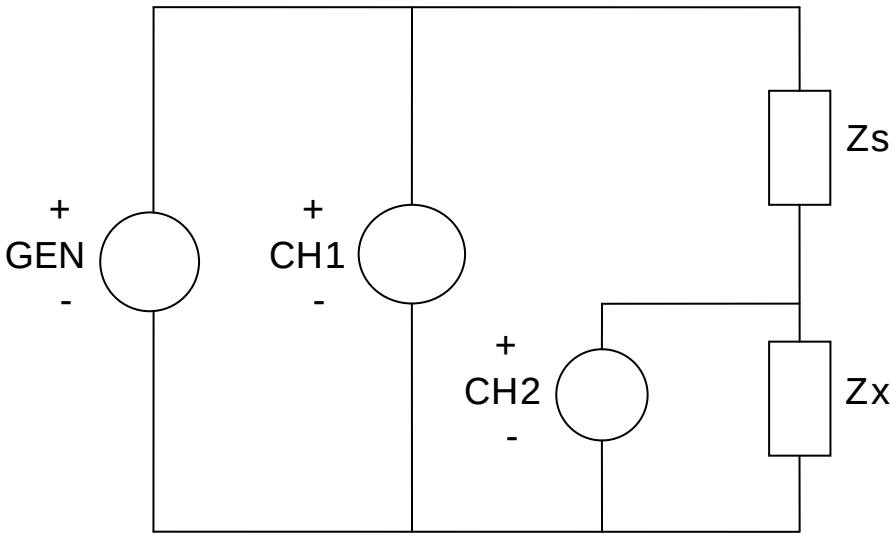
Measurements can be made without the active head by simply connecting a series shunt (set the LCR head option in the SETUP menu to ‘none’). This allows measurements to be made at the full operating voltage range of PsimetriQ. The shunt chosen must be appropriate for the voltage, the current and the frequency of operation.

There are three manual connection options, “shunt”, “divider Zx low”, “divider Zx high”.



For “shunt” connection, shown above, the current is measured directly across the shunt using CH2 while the voltage across the Zx is measured by CH1. Notice that the positive inputs to both CH1 and CH2 are connected to the midpoint to minimise common mode loading effects.

Then: Zx = Zs x CH1 / CH2



For “divider Zx low” connection, shown above, the total voltage is measured by CH1 and the voltage arising from the potential divider effect of Zs and Zx is measured by CH2. Notice that all the negative terminals are connected together.

Then: Zx = Zs / ((CH1 / CH2) – 1)

The connections for “divider Zx high” are the same as above but with Zx in the high arm of the potential divider and the shunt in the low arm.

Then: Zx = Zs x ((CH1 / CH2) – 1)

PsimetriQ measures the real and imaginary components at the fundamental frequency using DFT analysis as described in the section on gain/phase analysis. The frequency may be taken from its own generator or from the circuitry under test.

From the fundamental components of voltage, (a + jb), and those of the current, (c + jd), PsimetriQ computes the complex impedance given by:

$$\mathbf{z} = \mathbf{v} / \mathbf{i}$$
$$= (a + jb) / (c + jd)$$

The components of the complex impedance are filtered independently to minimise the effects of noise, which would have random phase and would therefore be filtered out.

The magnitude of the voltage and current are also computed.

From the complex impedance the following parameters can be derived:

- ac resistance
- inductance,
- capacitance
- impedance (magnitude, resistance and reactance)
- phase
- tanδ (= real/imaginary)
- Q factor (= imaginary/real)

Values are displayed for both series and parallel configurations.

Optionally, the values can be expressed as admittance, conductance, and susceptance instead of impedance, resistance and reactance.

If the parameter option in LCR menu is set to ‘auto’, PsimetriQ will display capacitance or inductance according to the phase of the measurement. Alternatively, the display can be forced to capacitance, inductance or impedance.

Capacitance is displayed with tanδ, inductance is displayed with Q factor, and impedance is displayed in its resistive + reactive form and as magnitude. The phase of the impedance is displayed with all options.

The operating conditions for the component under test may be selected manually or PsimetriQ will automatically try to find appropriate conditions.

When measuring large electrolytic capacitors, it may be necessary to add an appropriate bias voltage to polarise the electrodes. In this case it may be necessary to select ac coupling in the CH1 menu in order to reliably measure the small ac voltage present.

When measuring small inductance or capacitance, it may be necessary to zero out the stray effects from the test connections. Press ZERO to access the compensation menu. For inductance connect together the test leads to a good short and select “short circuit” – the message ‘SHORT CIRCUIT ZERO SET’ will be displayed; for capacitance disconnect the test leads and press ZERO – the message ‘OPEN CIRCUIT ZERO SET’ will be displayed. To remove the zero, press ZERO then press DELETE within 1.5s – the message ‘ZERO CLEARED’ will be displayed.

For repeated measurements under the same test conditions (eg. production testing of a batch of capacitors) it is possible to compensate for the inherent phase shift of the connection jig. Connect a known reference component to the system, enter the known phase shift of the component as the “phase reference” in the ZERO menu

and select “phase adjust”. PsimetriQ then applies a compensating vector rotation to all subsequent measurements.

PsimetriQ can operate either in real time mode at a single frequency where the measurements are filtered and updated on the display; or it can sweep a range of frequencies and present the results as a table or graphs. Before performing a sweep, either series circuit or parallel circuit must be selected.

The frequency points to be measured are specified with three parameters:

number of steps
start frequency
end frequency

PsimetriQ computes a multiplying factor that it applies to the start frequency for the specified number of steps. Note that due to compound multiplication it is unlikely that the end frequency will be exactly that programmed. The frequency sweep is initiated by the START key, and when completed the data can be viewed as a table or graphs or printed out.

The window over which the measurements are computed is adjusted to give an integral number of cycles of the input waveform. In real time mode the results from each window are passed through a digital filter equivalent to a first order RC low pass filter; in sweep mode each result comprises a single window without any filtering unless repeat sweep is selected.

Very good results can be obtained in a reasonable time using the medium speed setting (e.g. 50 points x ~1/3s ≅ 17s); for the very best results, use the slow setting (50 points x ~2.5s ≅ 125s or 2 minutes, 5 seconds).

The ZOOM function can be used to select up to four parameters from the display when in real time mode. It has no function following a sweep.

Although it is most usual to use the PsimetriQ generator when performing LCR measurements, there may be circumstances where this is impractical, for example measuring the inductance of a transformer primary winding under load. In this case, turn off the PsimetriQ generator (OUT menu) and the frequency reference for the analysis is measured from channel 1. Provided that the signal is clean enough for an accurate frequency measurement (and for DFT analysis the frequency does need to be accurately known), then the measurements can be made reliably.

When using an external frequency reference there can be no sweep function.

14.1 LCR meter specification

LCR meter	
frequency	10uHz to 1MHz (own generator) 20mHz to 500kHz (external source)
measurement type	DFT analysis
measurements	L, C, R (ac), Q, tanδ, impedance, phase, admittance series or parallel circuit
conditions	auto, or manual
display	numeric values table of sweep results graph of any measurement
ranges (with external shunt)	100pF to 100uF 1μH to 100H 1Ω to 1MΩ
ranges (with active head)	10pF to 1000uF 100nH to 10kH 10mΩ to 100MΩ
basic accuracy	0.1% + Tolerance of Shunt
sweep step rate	1/20s, 1/3s or 2.5s (approx.)

Conditions:

23ºC +/- 5ºC ambient temperature
instrument allowed to warm up for ≥30 minutes
ac+dc coupling
autoranging or manual ranging ≥ 1/3 range
both signals < 10V peak

15 Harmonic analyser

The PsimetriQ harmonic analyser computes multiple DFTs on the input waveforms in real time (refer to the chapter on frequency response analysis for the formulae for DFT analysis).

There are three modes of operation: single harmonic, difference thd, and series thd. In single harmonic mode, the specified harmonic is displayed both in Volts and as a ratio to the fundamental; in either thd mode, the computed thd and a specified harmonic are displayed as a ratio to the fundamental.

In difference thd mode, the thd is computed from the rms and fundamental:

$$thd = 1/h_1 \sqrt{(rms^2 - h_1^2)}$$

In series thd mode, the thd is computed from a series of up to 64 harmonics.

$$thd = 1/h_1 \sqrt{\sum_{i=2}^{i=n} h_i^2}$$ where h_i is the i^{th} harmonic

In series mode the magnitude and phase of all the harmonics can be seen as a table or the magnitudes can be displayed as a bargraph which changes in real time with the measurements. When viewing the bargraph, ZOOM+ and ZOOM- change the vertical axis by a factor of 10.

In all cases the harmonics are phase referred to CH1 fundamental so that their in-phase and quadrature components may be separately filtered to minimise noise.

The single harmonic and the thd are expressed relative to the fundamental either as a percentage or in dB, as selected via the HARM menu.

PsimetriQ can operate either in real time mode at a single frequency where the measurements are filtered and updated on the display; or it can sweep a range of frequencies and present the results as a table or graphs.

The frequency points to be measured are specified with three parameters:

- number of steps
- start frequency
- end frequency

PsimetriQ computes a multiplying factor that it applies to the start frequency for the specified number of steps. Note that due to compound multiplication it is unlikely that the end frequency will be exactly that programmed. The frequency sweep is initiated by the START key, and when completed the data can be viewed as a table or graphs or printed out.

The window over which the measurements are computed is adjusted to give an integral number of cycles of the input waveform. In real time mode the results from each window are passed through a digital filter equivalent to a first order RC low pass filter; in sweep mode each result comprises a single window without any filtering.

Very good results can be obtained in a reasonable time using the medium speed setting (e.g. 50 points x ~1/3s ≅ 17s); for the very best results, use the slow setting (50 points x ~2.5s ≅ 125s or 2 minutes, 5 seconds).

The ZOOM function can be used to select up to four parameters from the display when in real time mode. It has no function following a sweep.

Although it is most usual to use the PsimetriQ generator when making harmonic measurements, there may be circumstances where this is impractical, for example measuring harmonic currents drawn from the mains. In this case, turn off the PsimetriQ generator (OUT menu) and the frequency reference for the analysis is measured from channel 1. Provided that the signal is clean enough for an accurate frequency measurement (and for DFT analysis the frequency does need to be accurately known), then the measurements can be made reliably.

When using an external frequency reference there can be no sweep function.

15.1 Harmonic analyser specification

Harmonic analyser	
fundamental frequency	100uHz to 500kHz (own generator) 20mHz to 500kHz (external source)
harmonic frequency	10uHz to 1MHz
measurement type	multiple DFT analysis
measurements	single harmonic, differential thd, thd by series of harmonics
max harmonic	64
max input	±100V peak, 50V rms
input ranges	100V, 30V, 10V, 3V, 1V, 300mV, 100mV, 30mV, 10mV
ranging	full auto, up only, or manual
input impedance	1M // 30pF (exc. leads)
magnitude accuracy	0.1% of fundamental + 0.01mV + accuracy of fundamental
sweep step rate	1/20s, 1/3s or 2.5s (approx.)

Conditions:

23ºC +/- 5ºC ambient temperature
instrument allowed to warm up for ≥30 minutes
ac+dc coupling
autoranging or manual ranging ≥ 1/3 range

16 Transformer analyser

The transformer analyser mode allows a comprehensive set of measurements to be performed on a transformer at a single frequency or automatically swept over a range of frequencies.

The tests available are:

- turns ratio
- inductance
- leakage inductance
- ac resistance and Q factor
- dc resistance
- interwinding capacitance
- magnetising current
- insertion loss
- return loss
- single harmonic distortion
- total harmonic distortion
- longitudinal balance

The transformer analyser function is invoked, and the test selected, by the MODE key.

The easiest way to connect to the transformer in the various configurations for the different test is to use the transformer analyser fixture (see accessories) that connects to the PsimetriQ BNC connectors and also to the PsimetriQ extension port. Using the fixture, with appropriate source and load resistors, the test configuration and winding selection is selectable from the front panel. Active buffers within the fixture minimise the effects of stray capacitance and inductance.

Measurements can be made without the automatic fixture by manually making the appropriate connections to the transformer and resistors (set the fixture option in the AUX menu to ‘none’).

The operating conditions for the component under test may be selected manually or for some tests (such as turns ratio) PsimetriQ will automatically try to find appropriate conditions.

PsimetriQ can operate either in real time mode at a single frequency where the measurements are filtered and updated on the display; or it can sweep a range of frequencies and present the results as a table or graphs. Before performing a sweep, the required test must be selected.

The ZOOM function can be used to select up to four parameters from the display when in real time mode. It has no function following a sweep.

Although it is most usual to use the PsimetriQ generator when performing transformer analysis, there may be circumstances where this is impractical, for example measuring the turns ratio of a transformer under load. In this case, turn off the PsimetriQ generator (OUT menu) and the frequency reference for the analysis is measured from channel 1. Provided that the signal is clean enough for an accurate frequency measurement (and for DFT analysis the frequency does need to be accurately known), then the measurements can be made reliably.

When using an external frequency reference there can be no sweep function.

16.1 Turns ratio

Turns ratio is computed from the real part of the complex ratio of CH2 divided by CH1 using DFT analysis at the fundamental frequency (refer to the chapter on gain/phase analysis for the formulae for DFT analysis). This technique gives good results even on ‘lossy’ transformers.

The polarity of the windings is indicated by a positive turns ratio for in phase windings and negative ratio for inverted windings.

A nominal number of turns may be entered using the SETUP menu if known and PsimetriQ will then also display the computed number of turns.

As the inputs are independent of the output it is possible to energise a third winding when measuring turns ratio, or only two windings may be used.

To manually connect a transformer for turns ratio, connect the PsimetriQ output to the winding to be energised, and the inputs to the two windings for the ratio.

Note that when using the transformer analyser fixture, the transformer is always energised through the source resistance.

Pressing ZERO makes the turns ratio read 1:1, and the computed number of turns equal to the value entered via SETUP. This allows accurate testing of transformers or chokes against a known good reference. Press ZERO followed by DELETE to restore true turns ratio measurement.

16.2 Inductance & leakage inductance

The inductance of a winding is computed from the complex ratio of CH1 (voltage across the winding) divided by CH2 (current through the winding) using DFT analysis at the fundamental frequency (refer to the chapter on gain/phase analysis for the formulae for DFT analysis).

CH2 is forced to be external shunt input – enter the value of the external shunt as the source resistance via the SETUP menu.

To manually connect a transformer for inductance measurement, connect an appropriate source resistance in series with the winding and connect the PsimetriQ output across the series combination of the source resistance and winding. Connect the CH1 input across the winding to measure the voltage, and CH2 across the series resistance (note that the polarity of external shunt input is the opposite of that for voltage). Leave all other windings open.

To manually measure leakage inductance, use the same set up as for inductance but short the other windings.

When using the transformer analyser fixture, the connections for inductance or leakage inductance are made automatically by relays.

When measuring small inductance it may be necessary to zero out stray effects by replacing the winding with a good short and pressing ZERO. The message ‘ZERO SET’ will be displayed. To remove the effect of the zero press ‘ZERO’ followed ‘DELETE’ within 1.5s and the message ‘ZERO CLEARED’ will be displayed.

16.3 AC resistance and Q factor

AC resistance is measured the same way as inductance with CH1 monitoring the voltage across the winding, and CH2 monitoring the current through it via the external shunt (source resistance).

The Q factor measurement is an effective way of detecting a shorted turn – either on a transformer, or on a choke when using the transformer analyser fixture TAF02. When using suitable conditions (often very different from the normal operating conditions of the device under test) the Q factor changes dramatically when a shorted turn is present.

16.4 DC resistance

DC resistance is measured with the same circuit arrangement as inductance and ac resistance, but dc signals are used (refer to the chapter on the rms voltmeter for the formulae for dc analysis).

16.5 Interwinding capacitance

The interwinding capacitance of a transformer is computed from the complex ratio of CH1 (voltage across the transformer) divided by CH2 (current through the transformer) using DFT analysis at the fundamental frequency (refer to the chapter on gain/phase analysis for the formulae for DFT analysis).

CH2 is forced to be external shunt input – enter the value of the external shunt as the source resistance via the SETUP menu.

To manually connect a transformer for interwinding capacitance measurement, connect an appropriate source resistance in series with one winding and connect the PsimetriQ output across the transformer from the series resistance to another winding. Connect the CH1 input across the transformer from one winding to the other to measure the voltage across the windings, and CH2 across the series resistance (note that the polarity of external shunt input is the opposite of that for voltage).

When using the transformer analyser fixture, the connections for interwinding capacitance are made automatically by relays.

When measuring small capacitance it may be necessary to zero out stray effects by disconnecting the transformer and pressing ZERO – the message ‘ZERO SET’ will be displayed. The transformer analyser fixture TAF01, has a stray capacitance of around 60pF that can be zeroed out this way. To remove the effect of the zero press ‘ZERO’ followed ‘DELETE’ within 1.5s and the message ‘ZERO CLEARED’ will be displayed.

16.6 Magnetising current

The magnetising current is the current drawn by the primary, energised under normal operating conditions but without any secondary load. It is typically measured on power transformers rather than signal transformers so although the transformer analyser fixture, TAF01, will select appropriate relays to make the measurement it is more common that a manual connection or a custom fixture would be used.

The magnetising current is measured as the true rms value (refer to the chapter on the rms voltmeter for the formulae for rms analysis) so it will include all distortion components.

To manually connect a transformer for magnetising current measurement, connect an appropriate shunt in series with the primary. When selecting the shunt, bear in mind the current that it must pass, the resulting voltage drop across it, and the power that will be dissipated in it. Connect CH1 directly across the primary winding, and CH2 across the series resistance (note that the polarity of external shunt input is the opposite of that for voltage). Ensure that all connections and the series resistance are appropriate for the voltage, the current and the frequency of operation.

Energise the primary so that the voltage seen at the primary after the series resistance, is the normal operating voltage.

16.7 Return loss

Return loss is a measure of impedance mismatch in signal transformers that are terminated with the design load resistance.

The secondary winding is terminated with the appropriate load resistance and the primary is energised via a source resistance that is equal to the resistance that should be reflected back from the secondary (load resistance * (turns ratio)^2). The impedance looking into the primary is measured.

If **z** is the complex impedance measured at the primary, and R is the source resistance then the return loss is given by:

$$\text{return loss} = | \mathbf{z} + R | / | \mathbf{z} - R |$$

Return loss is usually expressed in dB:

$$= 20 \log (| \mathbf{z} + R | / | \mathbf{z} - R |) \text{ dB}$$

As a figure of merit, a higher value of return loss indicates a better transformer.

The circuit arrangement for return loss is the same as that for inductance measurement except that the secondary is terminated with the appropriate load resistance.

As the value of the load source resistance, R, is used in the computation, it is important that this value be entered via the MODE menu.

16.8 Insertion loss

Insertion loss is a measure of power loss due to impedance mismatch in signal transformers that are terminated with the design load resistance.

The secondary winding is terminated with the appropriate load resistance and the primary is energised via a source resistance that is equal to the resistance that should be reflected back from the secondary (load resistance * (turns ratio)²). The voltage energising the series resistance and primary winding is measured and the voltage on the secondary is measured.

If Rs is the source resistance, the power into the transformer is computed as:

$$Win = Vin^2 / 4\,Rs$$

If Rl is the load resistance, the power out is computed as:

$$Wout = Vout^2 / Rl$$

Insertion loss then is given by:

$$\text{Insertion loss} = Win / Wout$$
$$= (Vin / Vout)^2 \,.\, Rl / 4\,Rs$$

Insertion loss is usually expressed in dB:

$$= 10 \log ((Vin / Vout)^2 \,.\, Rl / 4\,Rs)\ dB$$

As a figure of merit, a lower value of insertion loss indicates a better transformer.

To manually connect a transformer for insertion loss measurement, fit the appropriate source resistance in series with the primary winding then connect the PsimetriQ

output and CH1 input across the series combination of the source resistance and the primary winding. Connect the appropriate load resistance and Ch2 input across the secondary.

When using the transformer analyser fixture, the connections for insertion loss are made automatically by relays.

As the values of the load resistance, Rl, and the source resistance, Rs, are used in the computation, it is important that both values are entered via the MODE menu.

16.9 Harmonics and distortion

Harmonic distortion introduced by a signal transformer may be measured either at a single spot harmonic or as the thd computed from a series of harmonics.

The primary of the transformer is energised either by the output of PsimetriQ or by external means and CH2 is connected across the secondary. It is usual to measure harmonic distortion with the secondary loaded.

Specify the single harmonic, or the maximum series harmonic via the SETUP menu.

PsimetriQ analyses for up to 50 harmonics in real time, using multiple DFTs (refer to the chapter on gain/phase analysis for the formulae for DFT analysis). Each harmonic is individually phase referenced to the fundamental so that the in-phase and quadrature components can be separately filtered. As the harmonics are usually very small, this technique is important to give adequate noise rejection.

The series harmonic data is combined to give the thd (refer to the chapter on harmonic analysis for the thd formula).

The single harmonic and the thd are expressed as dB relative to the fundamental.

16.10 Longitudinal balance

Longitudinal balance is a measure of the common mode rejection ratio, CMRR, of the transformer.

Longitudinal balance requires external circuitry to give the required accuracy – a plug in module is available for the transformer analyser fixture, TAF01, with precision resistors and active buffers adjacent to the transformer pins to minimise stray effects.

As a figure of merit, a higher value of longitudinal balance indicates a better transformer.

Transformer analyser specification

Transformer analyser	
frequency	10uHz to 1MHz (own generator) 20mHz to 500kHz (external source)
measurement type	DFT analysis, true rms as appropriate
measurements	turns ratio turns inductance leakage inductance ac resistance dc resistance interwinding capacitance insertion loss return loss harmonics thd longitudinal balance
conditions	auto, or manual
display	numeric values table of sweep results graph of any measurement
accuracy	refer to other functions
sweep capability	all ac functions
sweep step rate	1/20s, 1/3s or 2.5s (approx.)

Appendix A – Accessories

ACCESSORIES

Power meter adaptors

The power meter adaptors allow easy and safe connection of the PsimetriQ to a mains appliance under test to measure the power or harmonics.

The appliance under test plugs into an IEC mains outlet on the adaptor, which contains an isolating voltage transformer and current transformer with precision low resistance shunt.

The adaptor is fitted with an IEC mains inlet for use with an appropriate mains lead.

When the adaptor is plugged into the mains and the mains switched on, the appliance is energised and PsimetriQ can be used to measure the power or harmonics.

Leave the PsimetriQ generator off (OUT menu) so that it will synchronise to the mains frequency.

Part numbers

500-058 IEC 10A power meter adaptor

75Ω / 600Ω output adapter

The generator output from the PsimetriQ has a series impedance of 50Ω. The output adapter fits directly onto the front of the instrument and provides 2 outputs:

75Ω via a BNC connector
600Ω via 4mm sockets.

There are two versions of the adapter that have different spacing between the 4mm sockets:

½" (12.5mm) as commonly used for communications.
¾" (19mm) as standard on instruments.

In both cases, the red connector carries the output signal, the green or black connector is 0V (connected to earth via the PsimetriQ chassis).

The impedance conversion is resistive and does not limit the frequencies available from the generator (dc coupled). When driving into the characteristic impedance (75Ω or 600Ω as appropriate) the voltage delivered to the load will be half that delivered into open circuit.

Matching the source to the load impedance minimises reflections at higher frequencies and improves transient response, especially when driving long lengths of cable or transformers.

Part numbers

500-005	75/600Ω adaptor with ½" spacing
500-026	75/600Ω adaptor with ¾" spacing

LCR active head

The PsimetriQ LCR active head fits onto the front of the instrument, making connection to the output and the two inputs, to provide four BNC connections for use with Kelvin leads to connect to the component under test.

A cable from the active head connects to the AUX port on the front of the PsimetriQ to allow selection of one of the three internal shunts:

shunt	value	purpose
normal	100Ω	general purpose, all frequencies
high	10kΩ	higher impedance, low to medium frequency
very high	1MΩ	impedance > 100kΩ, low frequency only

*Ensure you have enabled the “LCR Active Head” in the AUX menu.

The active head contains high impedance buffer amplifiers that help to reduce the effect of stray capacitance and inductance.

The active head is usually supplied with Kelvin clip leads but Kelvin test probes are also available for in-circuit testing.

Part numbers

500-056	LCR active head
510-013	Kelvin clip lead set
510-014	Kelvin test probe set

Transformer analyser fixture, TAF01

The transformer analyser fixture TAF01 consists of a relay switching base unit that accepts plug in module to interface to transformers.

It connects to the BNC connectors on the front of PsimetriQ and is controlled by PsimetriQ via the extension port.

It supports transformers with 2 single windings, or with 1 single winding and one split winding. The winding(s) to be used for a measurement may be controlled by the front panel or by communications.

The connections to the transformer may be made either by a plug in pcb with suitable ZIF socket and resistors, or by flying leads with cable clips. To use the latter, plug in a resistance carrier board with appropriate source and load resistors.

NB it is essential that a source resistor be fitted for all tests.

The fixture contains high impedance buffer amplifiers that help to reduce the effect of stray capacitance and inductance.

Part numbers

500-017	TAF01 transformer analyser fixture
500-019	plug in module for modem transformers
500-020	plug in module for longitudinal balance
500-021	plug in resistance carrier
500-044	plug-in terminal block module
510-015	TAF01 Kelvin lead set
509-004	UK mains PSU

Isolation transformer

When testing the stability of control loops it is necessary to inject a small disturbance signal into the loop. PsimetriQ output is ground referenced so it is necessary to isolate the output before it can be connected to the loop.

The standard isolation transformer provides an isolated output at a reduced signal level of about 1/6 of the direct output level over a frequency range of about 10Hz to 200kHz.

Other isolation transformers are available for high frequency or high voltage applications.

Connections are via BNC connectors – one is grounded to the case the other is isolated. The grounded connector should be connected to the OUTPUT connector of PsimetriQ – the isolated connector should be wired to the circuit under test.

Part numbers

500-042	standard injection transformer
500-047	High frequency injection transformer
500-048	High Voltage injection transformer
500-070	Low frequency injection module

CommVIEW PC software

CommVIEW is a self contained software program for a PC, which facilitates communication with PsimetriQ over RS232.

CommVIEW allows strings to be sent and received between a PC and PsimetriQ. The strings can be viewed in a window and optionally stored in a file. Data received from PsimetriQ may be displayed in normal scientific notation with an identifying label.

Strings to be sent to PsimetriQ can be stored in a “script file” and executed automatically. The script file is created with any text editor and includes three types of lines (interpreted by the first character on each line):

lines beginning with " are sent to PsimetriQ
lines beginning with # are commands for CommVIEW
any other line is a comment.

The # commands that are recognised:

#beep	*sound the beeper on the PC*
#label,i,string	*apply a label to data value[i]*
#pause,t	*wait for time t*
#reply,t	*wait time t for a reply*

For an example script file, look at example.scr on the CommVIEW release disc.

Other functions in CommVIEW:

save results	*results menu*
set COM port parameters	*configure menu*
firmware upgrade	*instrument menu*
read/store user programs	*instrument menu*

Appendix B – Serial command summary

command format	reply format
*CLS	
*ESE,value	
*ESE?	single integer data value
*ESR?	single integer data value
*IDN?	company,product,serial no,version
*OPC?	0 or 1
*RST	
*SRE,value	single integer data value
*SRE?	
*STB?	single integer data value
*TRG	
*TST?	single integer data value
*WAI	
ABORT	
ACTRIM,channel,level,tol	
ALARM,latch,sounder	
ALARM?	single integer data value
ALARME,value	
ALARME?	single integer data value
ALARM1,type,data,high,low	
ALARM2,type,data,high,low	
AMPLIT,amplitude	
ANALOG,type,value1,value2	
BEEP	
BLANKI,on/off,threshold	
CONFIG,parameter,data	
CONFIG,parameter?	single integer or real data value
COUPLI,channel,coupling	
COUPLI,channel?	single integer data value
DATALO,function,interval	
DATALO,start,records?	index,time,data… one record per line
DAV?	single integer data value
DAVER,value	
DAVER?	single integer data value
FILTER,type,dynamics	
FRA	
FRA?	freq,mag1,mag2,dB,phase
FRA,SWEEP?	n lines of GAINPH? data
FREQUE,frequency	
FSWEEP,steps,start,end	

GAINPH	
GAINPH?	freq,mag1,mag2,dB,phase
GAINPH,SWEEP?	n lines of GAINPH? data
HARMON,scan,para,h,hmax	
HARMON?	freq,mag1,mag2,hmag1,hmag2,h1,h2
or	freq,mag1,mag2,thd1,thd2,h1,h2
HARMON,SWEEP?	n lines of HARMON? data
HARMON,SERIES?	mag1,%1,ϕ1,mag2,%2,ϕ2 1 line for each harmonic
HOLD,on/off	
INPUT,channel,type	
INPUT,channel?	single integer data value
KEYBOA,value	
LCR,conditions,param,head	
LCR?	freq, mag1, mag2, impedance, phase, R, L, C (series), R, L, C (parallel), tanδ, Q, reactance
or	freq, mag1, mag2, impedance, phase, resistance, reactance, admittance, phase, conductance, susceptance
LCR,SWEEP?	n lines of data: freq,QF,tanδ,impedance,phase,L,C,R
or	freq,QF,tanδ,admittance,phase,L,C,R
LOWFRE,on/off	
MARKER,on/off,frequency	
MODE,type	
OFFSET,offset	
OUTPUT,type,sweep,phase	
PAV,parameter,scaling	
PAV?	freq,mag1,mag2,parameter,phase,a,b
PAV,SWEEP?	n lines of VECTOR? data
PHASE	
PHASE?	freq,phase
PHASE,STREAM,window	phase,phase,phase,phase,phase,…….
PHCONV,convention	
PHREF,channel	
POWER,integration type	
POWER,WATTS?	W,W.f,VA,VA.f,pf,pf.f,Wdc,W.h,freq
POWER,RMS?	rms1,rms2,dc1,dc2,fnd1,fnd2,ϕ1,ϕ2
POWER,INTEGR?	Wh,Wh.f,VAh,VAh.f,pf,pf.f,Ah,Ah.f,t
PPORT,value	
PPORT?	single integer data value
PROGRAM,function,number	
PROGRAM?	CR terminated text string

RANGE,ch,ranging,range	
RESOLU.format	
REZERO	
SCALE,channel,factor	
SCALE,channel?	single real data value
SHUNT,channel,resistance	
SHUNT,channel?	single real data value
SINGLE,on/off	
SPEED,speed	
SSWEEP,function,number	
START	
STATUS,channel?	range number,range text,over/low/ok
STOP	
STREAM,enable,window	
STREAM,disable	
STREAM?	data, data, data, data, data, …..
SUSPEND,on/off	
TFA	
TFA?	freq,mag1,mag2,dB,phase
TFA,SWEEP?	n lines of GAINPH? data
TXA,test,fixture,load,source	
TXA?	freq,mag1,mag2,parameter
TXA,SWEEP?	n lines of TXA? data
TXTEST,test,wind1,wind2	
USER?	3 CR terminated text strings
VECTOR,parameter,scaling	
VECTOR?	freq,mag1,mag2,parameter,phase,a,b
VECTOR,SWEEP?	n lines of VECTOR? data
VERSION?	datecode,cpu,dsp,fpga,boot
VRMS	
VRMS?	RMS? data followed by SURGE?
VRMS,RMS?	rms1,rms2,dc1,dc2,ac1,ac2,db1,db2
VRMS,SURGE?	pk1,pk2,cf1,cf2,surge1,surge2
WAVEFO,type	
ZERO	
ZERO,DELETE	
ZOOM,level,d1,d2,d3,d4	
ZOOM?	level,d1,d2,d3,d4

calibration commands

CALAPP	
CALCOM,freq	
CALFIL,index,value	
CALFIL?	six real data values
CALFRQ,index,freq	
CALFRQ?	seven real data values
CALIBR,index,value	
CALIBR?	single integer data value
CALPHA,index	
CALRES	
CALSAV,password	
CALSNO,serial number	
CALSTR,string	
CALSTR?	string

Appendix C – Available character set

The following characters can be selected in text entry mode.
The table is to be read across then down (eg, starting at space and repeatedly pressing NEXT gives ! “ # $ % & ‘ ( ) * etc.)

	!	“	#	$	%	&	‘
(	)	*	+	,	-	.	/
0	1	2	3	4	5	6	7
8	9	:	;	<	=	>	?
@	A	B	C	D	E	F	G
H	I	J	K	L	M	N	O
P	Q	R	S	T	U	V	W
X	Y	Z	[	\	]	^	_
‘	a	b	c	d	e	f	g
h	i	j	k	l	m	n	o
p	q	r	s	t	u	v	w
x	y	z	{	|	}		

Appendix D – Configurable parameters

All parameters can be accessed using the CONFIG command:

CONFIG,*parameter*?
CONFIG,*parameter,data*

Number	Function
	System parameters
1	operating mode
4	autozero manual or auto
5	blanking disable
6	phase convention
7	main output on/off
8	line drawing on/off
9	keyboard beep on/off
11	low frequency mode
12	user window size
13	measurement speed
14	filter type
15	filter dynamics
16	baud rate
17	program step enable
18	sweep steps
19	sweep start frequency
20	sweep stop frequency
21	single sweep / continuous sweep
22	auto conditions
23	auto shunt
	Input parameters
24	enable channel 1
25	enable channel 2
26	input range channel 1
27	input range channel 2
28	input ranging channel 1
29	input ranging channel 2
30	filter channel 1

31	filter channel 2
32	scale factor channel 1
33	scale factor channel 2
34	external shunt channel 1
35	external shunt channel 2
	General parameters
38	5/6 digit resolution
39	phase reference
	Display parameters
42	zoom level
43	function zoomed on 1
44	function zoomed on 2
45	function zoomed on 3
46	function zoomed on 4
47	display type
	Signal generator parameters
48	generator frequency
49	generator amplitude
50	generator offset
51	generator waveform
52	delta frequency
53	delta amplitude
54	generator amplitude in dBm
55	generator action at end of sweep
56	generator phase reset
	Datalog parameters
58	datalog memory type
59	datalog interval
	General parameters
64	frequency marker enable
65	marker frequency
66	program jump enable
67	PLC interface enable
	Power meter parameters

83	integration type
	Streaming parameters
95	data streaming
96	data streaming window size
	Harmonic analyser parameters
99	mode
100	selected harmonic
101	maximum harmonic
102	computation
	LCR sweep zero parameters
106	sweep compensation
107	compensation start frequency
108	compensation stop frequency
109	compensation steps
	System parameters
116	dBm level control
117	step message enable
118	display sequence
119	length units
	Transformer analyser parameters
121	test
122	fixture
123	winding 1
124	winding 2
125	source impedance
126	load impedance
127	nominal number of turns
	TAF control parameters
130	source winding
131	load
132	measure 1
133	measure 2
	LCR meter parameters
137	computation

138	series/parallel sweep
139	graph option
140	active head control
141	impedance lin/log
142	phase adjust value
143	reference impedance
144	reference type

gain/phase analyser parameters

147	phase or delay time selection
148	dB offset
149	gain/phase margin enable
150	ratio selection

System parameters

151	minimum number of cycles
152	delay time
153	IEEE address
154	LAN enable

Alarm functions

156	alarm 1 data
157	alarm 1 type
158	alarm 1 high threshold
159	alarm 1 low threshold
160	latching type
161	sounder enable

Analogue output parameters

164	analogue zero
165	analogue scale

Alarm functions

167	alarm 2 data
168	alarm 2 type
169	alarm 2 high threshold
170	alarm 2 low threshold

Graph functions

173	graph 2 manual/auto

174 graph 2 maximum
175 graph 2 minimum

Phase angle voltmeter parameters

177 computation
178 LVDT scaling
179 manual null meter ranging
180 null maximum
181 phase offset

Trim parameters

186 ac trim enable
188 ac trim level
190 trim tolerance

Graph parameters

192 log/linear sweep
193 graph 1 manual/auto
194 graph 1 scaling maximum
195 graph 1 scaling minimum

Appendix E – Contact details

Please direct all queries or comments regarding the PsimetriQ instrument or manual to:

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At Newtons4th Ltd. we have a policy of continuous product improvement and are always keen to hear comments, whether favourable or unfavourable, from users of our products.

An example comment form can be found at the end of this manual – if you have any comments or observations on the product please fill a copy of this form with as much detail as possible then fax or post it to us.

Alternatively send an e-mail with your comments.

PSM1700 PSIMETRIQ comments

serial number:	main release: dsp release: fpga release: boot release: (press SYS then LEFT)	date:

your contact details:

comments:

detailed description of application or circumstances:

Please post or fax to Newtons4th Ltd.